ROBOTS IN MANUFACTURING ENVIRONMENTS

MANUFACTURING INNOVATION INSTITUTE

PROPOSERS' DAY

RIME

ROBOTS IN MANUFACTURING ENVIRONMENTS

12 August 2016

AGENDA

- 0800 -0900: Registration and Networking
- 0900 – 0905: Conference Center Welcome
- 0905 – 0930: OSD Welcome
- 0930 – 1000: Institutes for Manufacturing Innovation - Objectives
- 1000 – 1015: Break
- 1005 – 1050: FOA Contracting Overview
- 1050 – 1150: FOA Robots in Manufacturing Environments Manufacturing Innovation Institute Overview
- 1150 - 1215: Initial Q&A
- 1215 – 1315: No Host Lunch (Teaming discussions among potential Proposers encouraged)
- 1315 – 1350: Additional Q&A
- 1350 – 1400: Concluding Remarks

CONFERENCE CENTER WELCOME

OSD WELCOME

Ms. Tracy Frost
DoD ManTech
ODASD(MIBP)

LINKEDIN COLLABORATIVE SITE

- https://www.linkedin.com/groups/8559628

- Provided for collaboration

- Will post contacts from "Want to Lead" and "Want to Team" boards

AGENDA

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- 0905 – 0930: OSD Welcome
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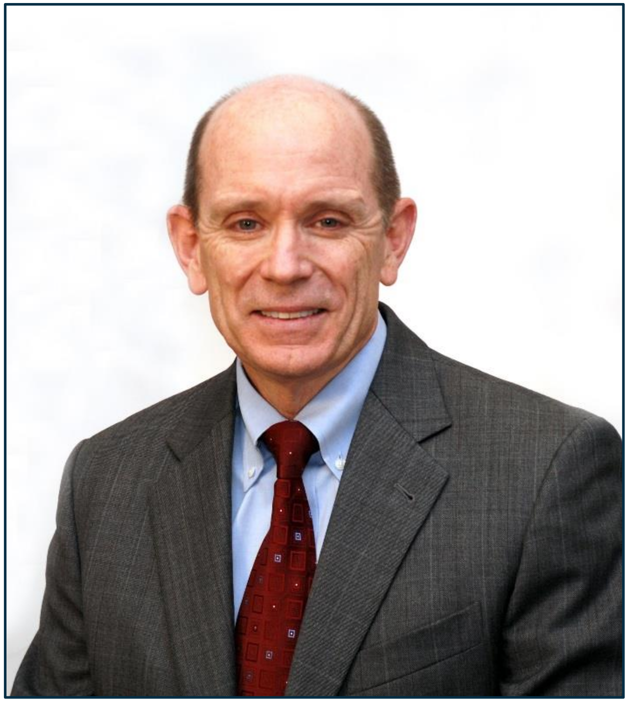


Mr. Scott Frost
ANSER
Manufacturing Technology (ManTech) Office
Office of the Deputy Assistant Secretary of Defense for Manufacturing and Industrial Base Policy (ODASD(MIBP))
U.S. Department of Defense

ODASD(MIBP) ManTech Office Roles and Responsibilities

ROBOTS IN MANUFACTURING ENVIRONMENTS MANUFACTURING INNOVATION INSTITUTE

- Oversee the DoD ManTech Program on behalf of USD(AT&L)
  - Work with Component ManTech Programs through the Joint Defense Manufacturing Technology Panel (JDMTP), S&T Enterprise
  - Provide an integrated program view; represent overall program to Congress, others
- Execute the Defense-wide Manufacturing Science & Technology (DMS&T) Program Element (a DoD ManTech Program component)
  - Cross-cutting, extremely high-leverage advanced manufacturing R&D investment vehicle for the Department
  - Core and Congressionally directed segments
- Support industrial readiness mission through active coordination across key ODASD(MIBP) functions
  - Manufacturing
  - Business Intelligence & Analytics
  - Industrial Base Assessments
  - Global Markets and Investments
- Actively support/lead national advanced manufacturing initiatives
  - Interagency/EOP collaboration: OSTP, DOC, DOE, DoEd, NASA, USDA, etc.
  - Congress, industry associations
  - Example initiative: National Network for Manufacturing Innovation (NNMI) Program

DoD ManTech Program Foundation and Purpose

Congressionally Mandated Mission

- Crucial transition link between technology invention and industrial applications
- Program looks beyond the normal risk of industry
- Key to affordable and timely acquisition and sustainment of weapon systems and components
- Broad R&D investment portfolio focused on cross-cutting, multi-system benefit to Defense Industrial Base

Key Metrics

- Increased affordability, producibility, reliability, and predictability of performance
- Decreased cycle time, manufacturing cost, system life cycle cost

ManTech Mission:

ManTech anticipates and closes gaps in manufacturing capabilities for affordable, timely, and low-risk development, production, and sustainment of defense systems.

ManTech carries out its mission through programs in the Military Departments, participating Defense Agencies, and OSD

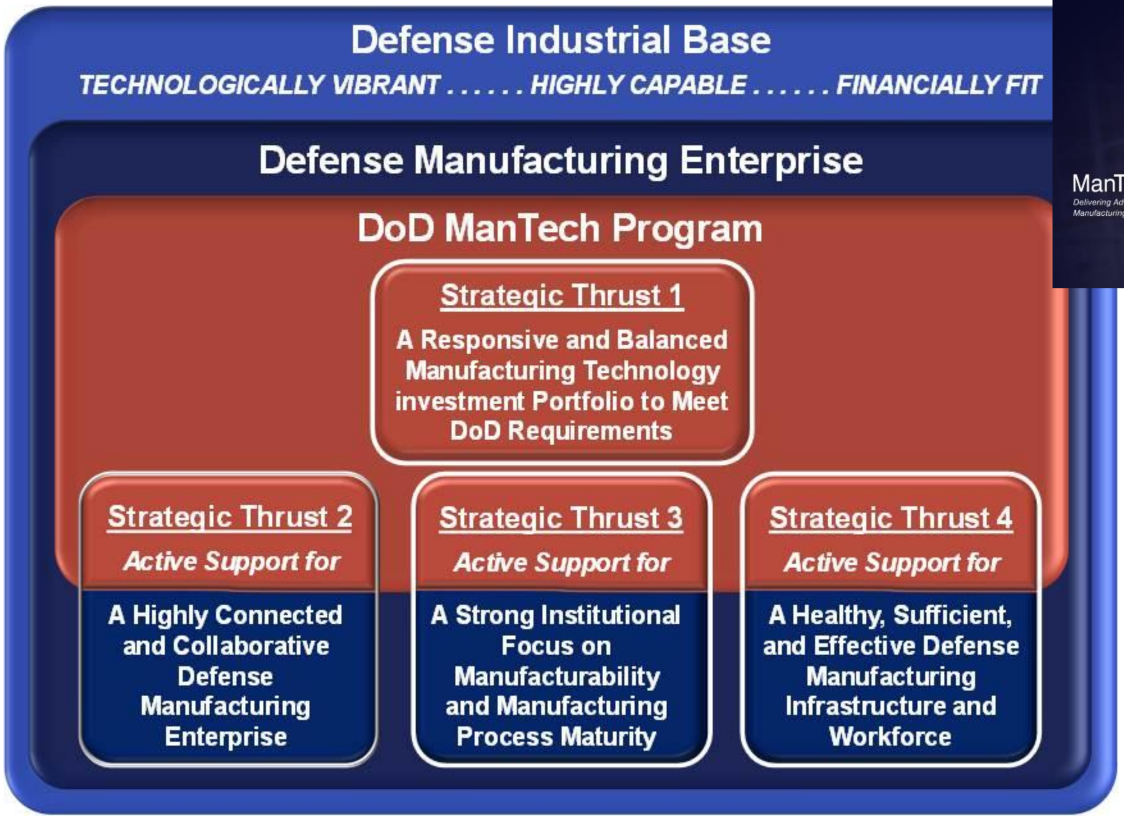
The DoD ManTech Program Strategy

Strategic Thrust 1: *"Responsive & Balanced Portfolio"*

Strategic Thrust 2: *"Highly Connected & Collaborative Enterprise"*

Strategic Thrust 3: *"Institutionalize 'Moving Manufacturing Left' " (earlier)*

Strategic Thrust 4: *"Infrastructure & Workforce"*



Delivering advanced manufacturing processes for robust & affordable technology transition powerfully contributes to a healthy and resilient industrial base.

Strategic Conclusion (Genesis of NNMI):

Compelling need to address market failure in pre-competitive applied manufacturing R&D

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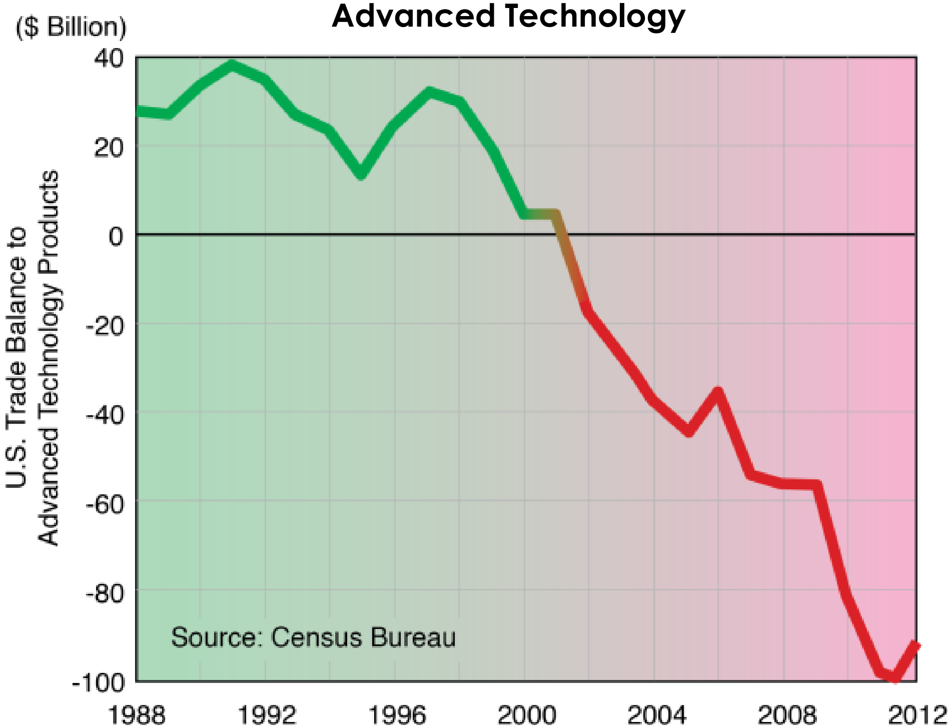
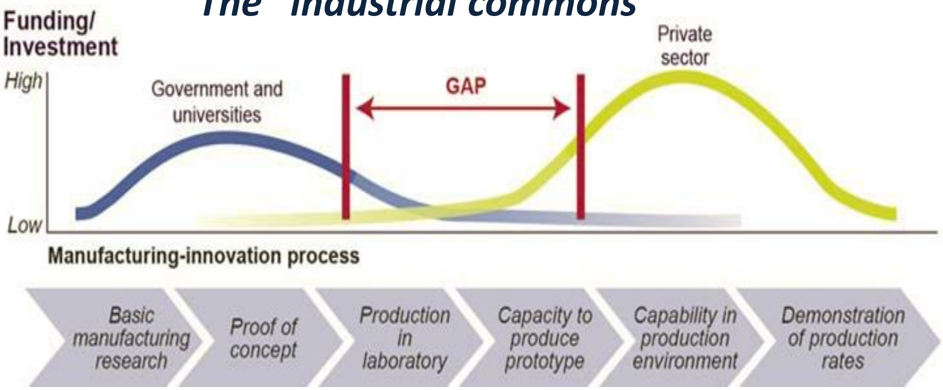
- *U.S. Trade Balance swung to historic deficit, lost 1/3rd of workforce*
- *High value products invented here, now made elsewhere*

U.S. Trade Balance of Advanced Technology



The "valley of death"
The "missing Bell Labs"
The "industrial commons"



<u>The requirement</u>: A framework for government, industry and academia to intensely collaborate on industry-relevant manufacturing problems

- **Address the market failure of industry underinvestment in "pre-competitive" applied R&D**
- **Focus on "de-risking" new technologies and materials to scale-up for U.S. manufacturers**

Executive Branch Action:

Follow-up to seminal report recommendations by President's Council of Advisors on Science and Technology (PCAST)

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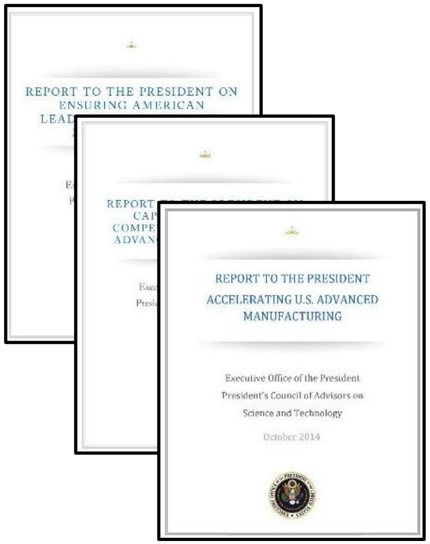

PCAST 2011, 2012 and 2014 Reports recommended, respectively:

- ***Advanced Manufacturing Initiative as national innovation policy***
- ***Manufacturing Innovation Institutes to address key market failure***
- ***Strong, collaborative network of Manufacturing Innovation Institutes***

Fundamentals:(1) Leverage USG's power to convene and industry's leadership long-term; (2) generate intense public-private collaboration through partnerships; (3) encourage regional clustering while generating national impact

2012 Presidential Actions:

- **Asks Congress to authorize initial network of up to 15 Manufacturing Innovation Institutes**
- **Directs Agencies to work together on Pilot Institute, while designing Institutes with input from Industry and Academia**

Established Interagency Advanced Manufacturing Coordination and Activity

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Executive Office of the President

Advanced Manufacturing Partnership
(AMP/PCAST)

Advanced Manufacturing National Program Office
(hosted by DOC - NIST)

NSTC - Advanced Manufacturing Subcommittee

Congressional Authorization: Revitalize American Manufacturing & Innovation Act

118 bipartisan RAMI Bill Sponsors

ROBOTS IN MANUFACTURING ENVIRONMENTS
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Rep. Tom Reed
R NY-23

Rep. Joe Kennedy
D MA-4

Sen. Sherrod Brown
D Ohio

Sen. Roy Blunt
R Missouri

September 15, 2014 – Passed House
100 Cosponsors (51D, 49R)

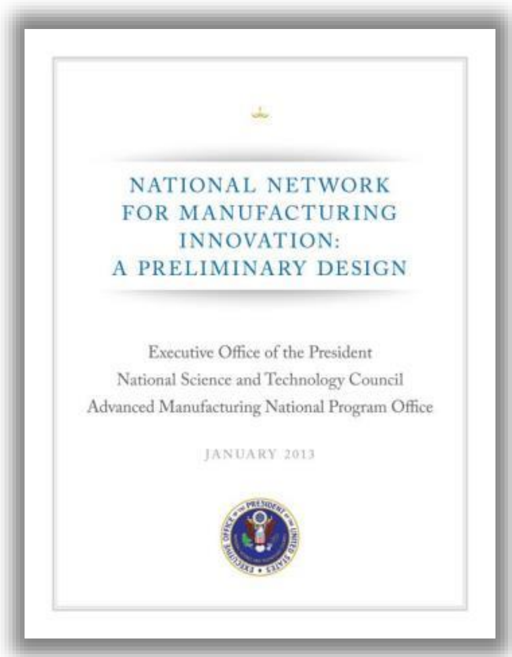
December 11, 2014 – Passed Senate with 2015 Appropriations
18 Cosponsors (10D, 7R, 1I)

December 16, 2014 – Signed By President Obama

Bipartisan Momentum Supporting the NNMI Initiative

The Manufacturing Innovation Institute (MII) Design

White House Report
NNMI Framework Design
January 2013


NATIONAL NETWORK FOR MANUFACTURING INNOVATION: A PRELIMINARY DESIGN

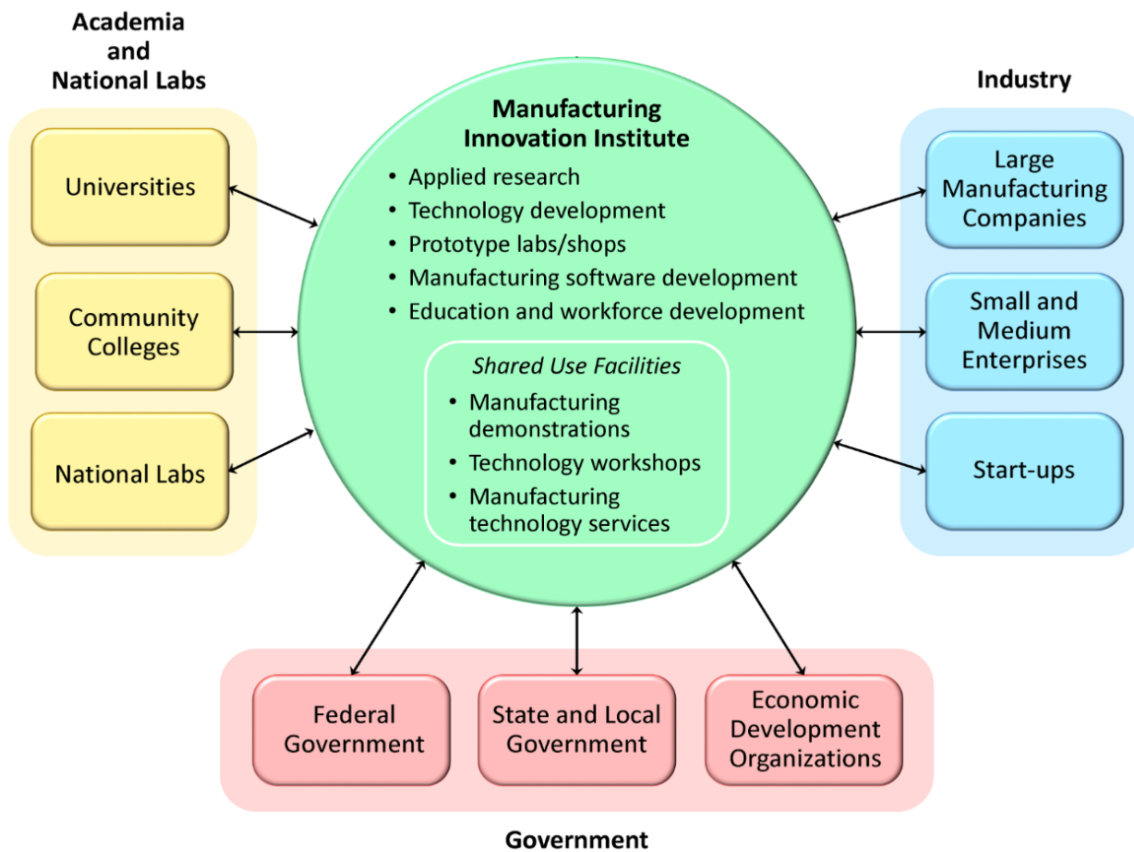
Executive Office of the President
National Science and Technology Council
Advanced Manufacturing National Program Office

JANUARY 2013

Creating the partnership space for sustained and powerful, pre-competitive collaboration between Industry, Academia and Government

MII Design Precepts:

- **Applied Research Focus: *Manufacturing* (*MRL 4-7*)**
- **Typically precompetitive R&D with broad industry benefit**
- **Strong education and workforce development component**



The Institute Summary

Applied Research + Education/Workforce Skills + Development of "Manufacturing Hubs"

The Federal investment in the National Network for Manufacturing Innovation (NNMI) serves to create an effective manufacturing research infrastructure for U.S. industry and academia to solve industry-relevant problems. The NNMI will consist of linked Institutes for Manufacturing Innovation (IMIs) with common goals, but unique concentrations. In an IMI, industry, academia, and government partners leverage existing resources, collaborate, and co-invest to nurture manufacturing innovation and accelerate commercialization.

As sustainable manufacturing innovation hubs, IMIs will create, showcase, and deploy new capabilities, new products, and new processes that can impact commercial production. They will build workforce skills at all levels and enhance manufacturing capabilities in companies large and small. Institutes will draw together the best talents and capabilities from all the partners to build the proving grounds where innovations flourish and to help advance American domestic manufacturing.

Federal startup investment: $70M - $120M/institute over 5 years
Institute Consortium owners must have minimum 1:1 co-investment

DoD and DoE Established or Announced MIIs

1. *America Makes* (The National Additive Manufacturing Innovation Institute)—DOD-Led; Established August 2012
2. *Power America* (Next Generation Power Electronics Manufacturing Innovation Institute)—DOE-Led; Announced January 2014
3. *Digital Manufacturing & Design Innovation Institute* (DMDII)—DOD-Led; Established February 2014
4. *LIFT -- Lightweight Innovations for Tomorrow* (Lightweight & Modern Metals Manufacturing Institute)—DOD-Led; Established February 2014
5. *Institute for Advanced Composites Manufacturing Innovation* (IACMI)—DOE-Led; Announced January 2015
6. *AIM Photonics – American Institute for Manufacturing Integrated Photonics*—DOD-Led; Established July 2015
7. *NextFlex* (Flexible Hybrid Electronics Manufacturing Innovation Institute) —DOD-Led; Established August 2015
8. *AFFOA* (Advanced Functional Fabrics of America) —DOD-Led; Established April 2016
9. *Smart Manufacturing Innovation Institute*—DOE-Led; Announced June 2016

Building a National Network of Institutes: Network Status and Growth Plans

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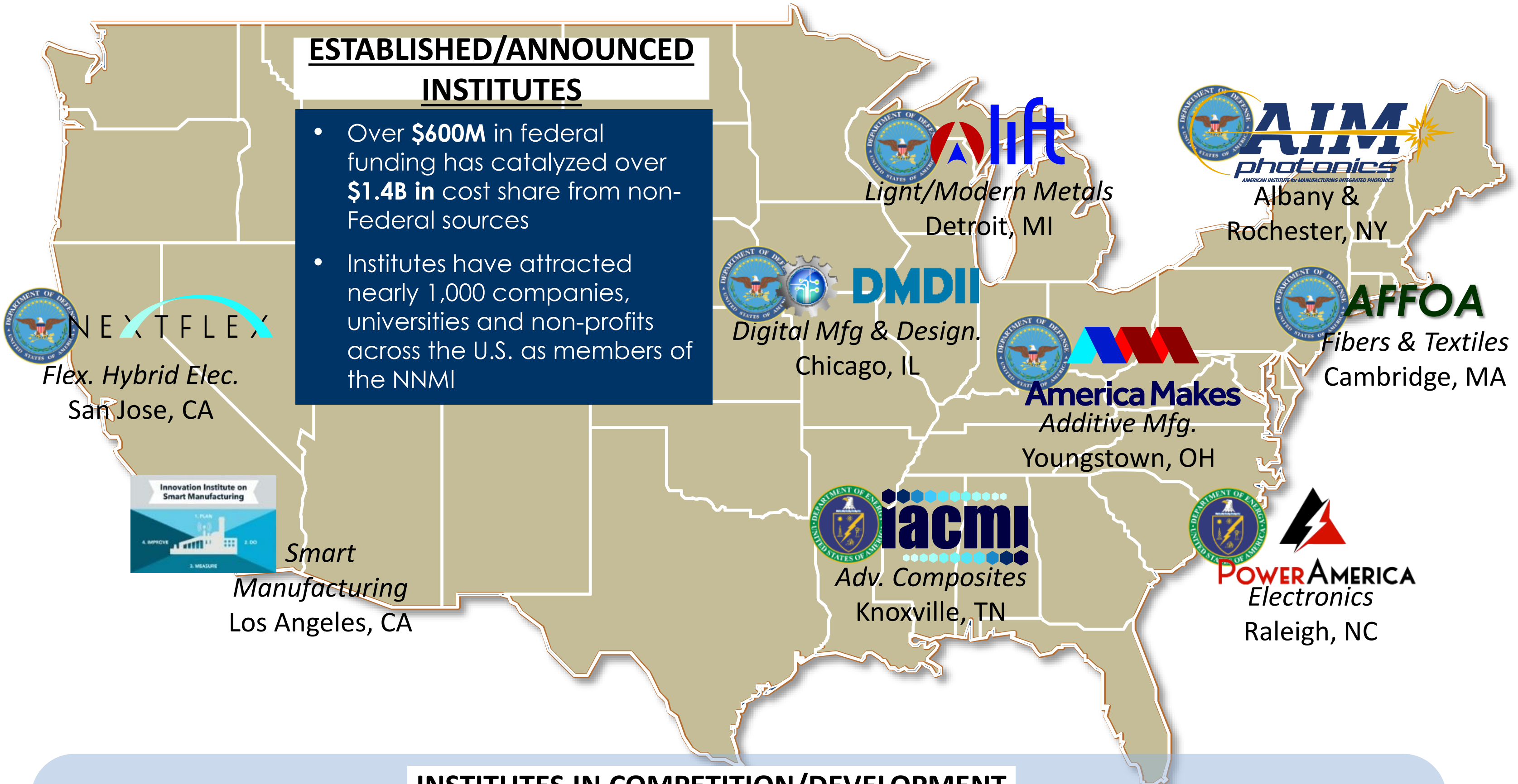
MANUFACTURING INNOVATION INSTITUTE

ESTABLISHED/ANNOUNCED INSTITUTES

- Over **$600M** in federal funding has catalyzed over **$1.4B in** cost share from non-Federal sources
- Institutes have attracted nearly 1,000 companies, universities and non-profits across the U.S. as members of the NNMI



INSTITUTES IN COMPETITION/DEVELOPMENT

Open Topic Competition for up to 2 MIIs

1. Advanced Tissue Biofabrication

2. Robotics in Manufacturing Environments

1. Modular Chemical Process Intensification

2. Reducing Embodied Energy and Decreasing Emissions

Manufacturing Innovation Institutes: Strategic Impact

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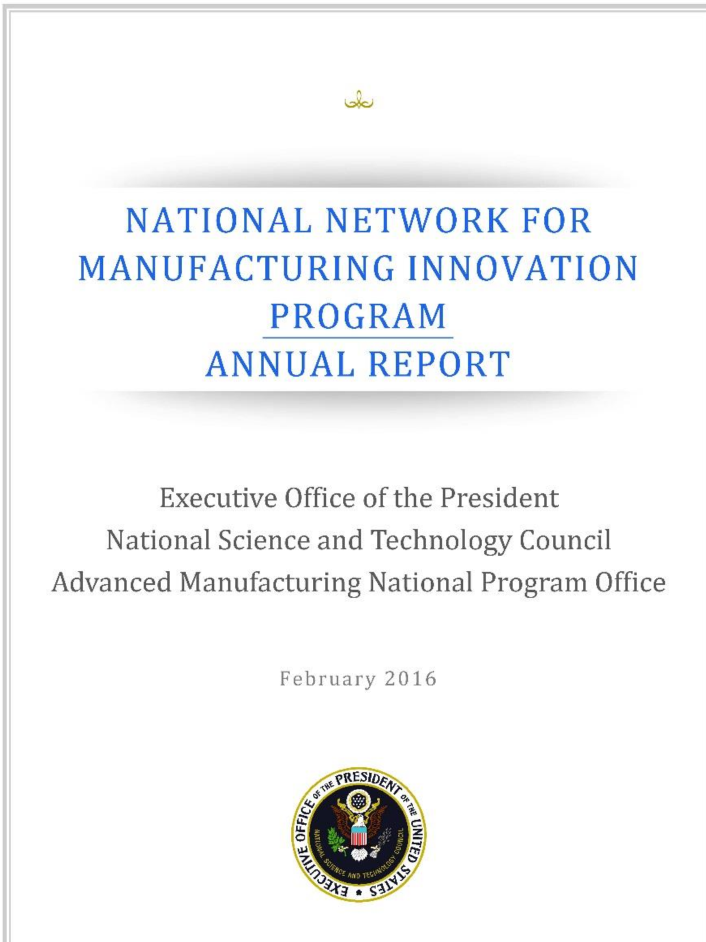
- ✓ Building a true national network of public-private partnerships, creating an industrial commons for manufacturing R&D and workforce education and development
  - Nearly 1,000 partners, 40+ states, $1.4 Billion in cost share
- ✓ Marshalling best talent across industry to both lead and participate
  - 100's of years of experience at every level
- ✓ Strategically aligning resources to address technology space
  - States and companies aligning funds and people to close gaps
- ✓ Catalyzing ecosystems across the Nation
  - Galvanizing communities – springboard for broader activity
  - Satellites enabling recruit AND retain
- ✓ Accelerating trust in supply chain development with diversified risks
  - Small and large companies gain exposure to each other in safe, collaborative environment
  - Institutes establish manufacturing capacities that were beyond the reach of even the largest companies

First NNMI Annual Reports Released

ROBOTS IN MANUFACTURING ENVIRONMENTS MANUFACTURING INNOVATION INSTITUTE



NATIONAL NETWORK FOR MANUFACTURING INNOVATION PROGRAM
ANNUAL REPORT

Executive Office of the President
National Science and Technology Council
Advanced Manufacturing National Program Office

February 2016

First Annual Report on the NNMI Program

NATIONAL NETWORK FOR MANUFACTURING INNOVATION PROGRAM
STRATEGIC PLAN

Executive Office of the President
National Science and Technology Council
Advanced Manufacturing National Program Office

February 2016

First Strategic Plan on the NNMI Program

NNMI:
A Game Changing Opportunity

ROBOTS IN MANUFACTURING ENVIRONMENTS
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- Establish a presence, at scale, to address the complexity of manufacturing scale-up
- Create an Industrial Commons, supporting future manufacturing hubs, with active partnering between all stakeholders
- Emphasize/support longer-term investments by industry
- Combine innovative R&D with workforce development and training
- ***Overarching Objective: Unleash new U.S. advanced manufacturing capabilities and industries - for stronger global competitiveness and economic & national security***

See www.manufacturing.gov and www.dodmantech.com

15 MINUTE BREAK

W911NF-16-R-0031 **OVERVIEW**

Kevin Bassler, U.S. Army Contracting Command - Aberdeen Proving Ground, RTP Division

AGENDA

- General Information
- Award Instrument
- Eligibility
- Foreign Participation
- Cost Share
- Evaluation Process
- Evaluation Factors
- Notification – Concept Papers
- Notification – Negotiation and Award
- Schedule

GENERAL INFORMATION

- Army Contracting Command – Aberdeen Proving Ground (Research Triangle Park) (ACC-APG(RTP))
  - Specialize in grants, cooperative agreements and other assistance instruments in addition to contracts
  - Primarily support Army Research Laboratory, Army Research Office and various other DoD initiatives

GENERAL INFORMATION

- **Read the FOA Instructions**

- Proposal Due Date and Times
  - Concept Papers Due 01 September 2016 no later than 3:00 PM local Durham, NC time.
  - Proposal due date and time will be specified at the time of Proposal Invitation

- Proposal Requirements, Sections
  - Reference Section IV of FOA for specific Concept Paper and Proposal Requirements and Sections

GENERAL INFORMATION

- **Read the FOA Instructions**

- Page Limitation
  - Concept Paper – 50 pages total
  - Proposal – 110 pages total

- Other Requirements
  - Concept Papers must be submitted to usarmy.rtp.rdecom-arl.list.RIME-foa@mail.mil
  - Full Proposals must be submitted via grants.gov

AWARD INSTRUMENT

- Technology Investment Agreement (TIA) under the authority of10 USC §2371, as implemented by the Department of Defense Grant and Agreement Regulations (DoDGARS)
  - https://www.gpo.gov/fdsys/pkg/CFR-2011-title32-vol1/xml/CFR-2011-title32-vol1-subtitleA-chapI-subchapC.xml (Part 37)
- Uniform Administrative Requirements, Cost Principles, and Audit Requirements for Federal Awards2 CFR 200
  - http://www.ecfr.gov/cgi-bin/text-idx?tpl=/ecfrbrowse/Title02/2cfr200_main_02.tpl

AWARD INSTRUMENT

- What is a Technology Investment Agreement (TIA)?
  - A special class of assistance instrument used to increase involvement of commercial firms in defense research programs and for other purposes related to integrating the commercial and defense sectors of the nation's technology and industrial base.
- Why a TIA?
  - Financial management systems
  - Patent rights/Intellectual Property

ELIGIBILITY

- **(See Section III of the FOA)**
- Limited to *U.S. non-profit organizations* who will serve as the lead and will be the recipient of the TIA
- The U.S. non-profit is expected to team with any combination of businesses, manufacturing firms, institutions of higher education, associated institutes, or non-profit industry consortia.

FOREIGN PARTICIPATION, ETC.

- The recipient of the award must be registered as a U.S. organization
- U.S. incorporated companies that are wholly owned subsidiaries of foreign companies may be eligible to be members of the RIME-MII, and sub-awardees
- FFRDC's are not eligible to receive an award under this FOA or team with an applicant

COST SHARE

- Minimum 1:1 Cost Share Required
  - AT LEAST $80M cost share
  - Cost-sharing is not required to precisely align with this funding profile on a yearly basis
- May Include
  - State and Local Funding (not origination from Federal dollars)
  - Private Sector Investment
  - In-Kind Cost Sharing
    - Equipment, facilities, man-power (see OMB Circulars, DoDGARs)

EVALUATION PROCESS

- 2 Step Process (Concept Paper and Proposal)
- Multi-Agency Scientific/Technical Review
  - Not a FAR Part 15 Source Selection Process
  - Evaluation Team is "Government Only"
- Evaluation Process
  - Preliminary review for proposal completeness, eligibility requirements, conformance with FOA requirements
  - Individual Proposals will be evaluated against the evaluation criteria – not against each other
- Award Selection:
  - Based on overall merit of proposal in response to the FOA, Agency need, and Available funding

EVALUATION CRITERIA

- The following four factors will be evaluated in descending order of importance: (1) Business Plan; (2) Technical Plan; (3) Educational Workforce Plan; and (4) Cost.
  - Factor 1 is broken down into 7 subfactors of equal importance.
  - Factor 2 is broken down into 3 subfactors of equal importance.

EVALUATION CRITERIA

- Factor 1: Business Plan
  - Assess the business plan which will describe how the RIME-MII will design, integrate and sustain the ecosystem within the membership and its external stake holders
- Factor 2: Technical Plan
  - Assess technical strategy, innovation beyond current practice, and personnel qualifications
- Factor 3: Educational and Workforce Plan
  - Asses the quality and degree of integration of educational and workforce/professional development and training to support advancing technology
- Factor 4: Cost

COST PROPOSAL

- Concept Paper
  - The cost portion of the Concept Paper shall include a ROM cost estimate. No detailed price or cost support information should be forwarded; only a time-phased bottom line figure should be provided.

- Proposal
  - Breakout of all costs by FY
  - Labor hours (mix and type), material costs, sub-recipient cost (breakout)
  - Supporting documentation (basis for cost estimate)
  - Vendor quotes for equipment/materials etc.
  - Basis for travel estimates etc.

COST PROPOSAL

- Cost will be evaluated on reasonableness and realism of the proposed costs, to include cost share, consideration of proposed budgets and funding profiles. Cost Realism Analysis will ensure proposed cost:
  - Is realistic for work to be performed
  - Reflects a clear understanding of the requirements
  - Is consistent with the unique methods of performance and material described in Applicants' technical proposals

NOTIFICATION – CONCEPT PAPERS

- Concept paper evaluations complete the week of 19 SEPTEMBER 2016
- Request for full proposal notification sent Mid-Late SEPTEMBER 2016
  - Only applicants invited to submit a proposal may do so
  - Unsuccessful concept paper proposers are encouraged to team with other entities
- Site visits may be scheduled
  - Dates TBD based on date of Proposal Invitations

NOTIFICATION – NEGOTIATION AND AWARD

- Selection for Negotiation Notification is not to be construed as an "assured award"
  - Successful Negotiations are required for award.
  - Inability to come to agreement on terms and conditions of the TIA within a reasonable time may result in moving to the next highest rated proposal.

Scheduled Award Date Mid-End of January 2017

SCHEDULE

MILESTONE	DATE
• Funding Opportunity Announcement	26 JULY 2016
• Proposer's Day 1	10 AUGUST 2016
• Proposer's Day 2	12 AUGUST 2016
• Concept Paper Due	01 SEPTEMBER 2016
• Proposal Invitation	MID-LATE SEPTEMBER 2016
• Proposals Due	Mid to late November 2016 (Will be specified in proposal invitation)
• Anticipated Award	MID-LATE JANUARY 2017

DISCLAIMER: This Presentation is provided for informational guidance only. If there are any discrepancies between the FOA and this Presentation, the FOA takes precedence.

ROBOTS IN MANUFACTURING ENVIRONMENTS MII OVERVIEW (RIME-MII)

Dr. Greg Hudas, Program Manager*, U.S. Army RDECOM-TARDEC*

Rick Meyers, Deputy Program Manager, *U.S. Air Force, AFRL*

AGENDA

- Introduction
- Government Team
- Background and Goals
- Vision
- RIME-MII Functional Ecosystem Concept
- Technology/Manufacturing Readiness Levels
- Standard Definitions
- Technology Thrust Areas
- Cross Cutting Focus Areas
- Collaborative Infrastructure
- Scope and Relationships
- Summary
- Evaluation Criteria

INTRODUCTION

- In early 2016, the government surveyed industry, through a Request for Information and open Workshops, to determine possible prospects for the next Manufacturing Innovation Institutes (MIIs)
  - Based on positive feedback from industry and academia, Robots in Manufacturing Environments (RIME) was chosen to move forward
- Over the last four months, the government has been developing a functional ecosystem concept for the role this MII can play as a public/private partnership to help strengthen this sector in the U.S. economy
- A team of government technology experts were assembled to develop the technical requirements for RIME-MII and develop the Funding Opportunity Announcement (FOA) released 26 July 2016

GOVERNMENT TEAM

ROBOTS IN MANUFACTURING ENVIRONMENTS
MANUFACTURING INNOVATION INSTITUTE

- OSD Leadership: Tracy Frost; Office of the Secretary of Defense (OSD), Manufacturing and Industrial Base Policy (MIBP)
- Contracting: Kevin Bassler; U. S. Army Contracting Command, Aberdeen Proving Ground, Research Triangle Park, NC.
- Institute Program Management:
  - Program Manager: Dr. Greg Hudas, US Army RDECOM-TARDEC (Tank-Automotive Research, Development, and Engineering Center)
  - Deputy Program Manager: Rick Meyers, US Air Force AFRL (Air Force Research Laboratory)
- Government SME Team: Comprised of Subject Matter Experts (SMEs) from across the government (Army, Air Force, Navy, DLA, DOE, DOC, NASA, NIST, NSF)

BACKGROUND

- Based on Request for Information (RFI), industry workshops, and government SME inputs, collaborative robotics for the manufacturing industry faces challenges in:
  - Geographic dispersion
  - Lack of affordable capability in specific technology areas, especially in human-robot and robot-robot collaboration
  - Manufacturing scalability and flexibility
  - Limited test, validation, and verification techniques (including modeling and simulation tools) to facilitate safety, security, and performance
  - Availability of a robust knowledge database that provides tools and data

GOALS

- Support an end-to-end ecosystem in the U.S. for RIME
- Be the innovation engine for design and a demonstration platform for industry
- Increase product performance, affordability (especially for small to mid-size industry), and market demand by fostering agile manufacturing advances
- Support applied R&D projects that enable new processes, robotic technologies and equipment, design tools, test methodologies, and capabilities
- Develop next-generation products, prototypes, and processes using highly trained labor, state-of-the-art technology and a robust knowledge management system

VISION

- Establish a national manufacturing institute to accelerate applied research, development, and demonstration in the application of collaborative robotic technologies in the manufacturing environment for defense and commercial customers
  - Affordable for small, mid, large size industries
  - Rapidly customized for small quantity and agile requirements
  - Enable and expand a domestic supply chain
- Establish a national manufacturing institute with the following attributes
  - Financially self-sustaining, world-leading, innovation hub that brings together private and public entities in **partnership** to develop, integrate, and accelerate next generation manufacturing technologies
  - Supports a core set of shared, applied Research and Development infrastructure that provides a clear center of gravity for the Institute and enables affordable access to physical and virtual tools and technologies
  - Leads in the ability to develop, design, test, validate, and field collaborative robotic technologies

FUNCTIONAL ECOSYSTEM CONCEPT

ROBOTS IN MANUFACTURING ENVIRONMENTS
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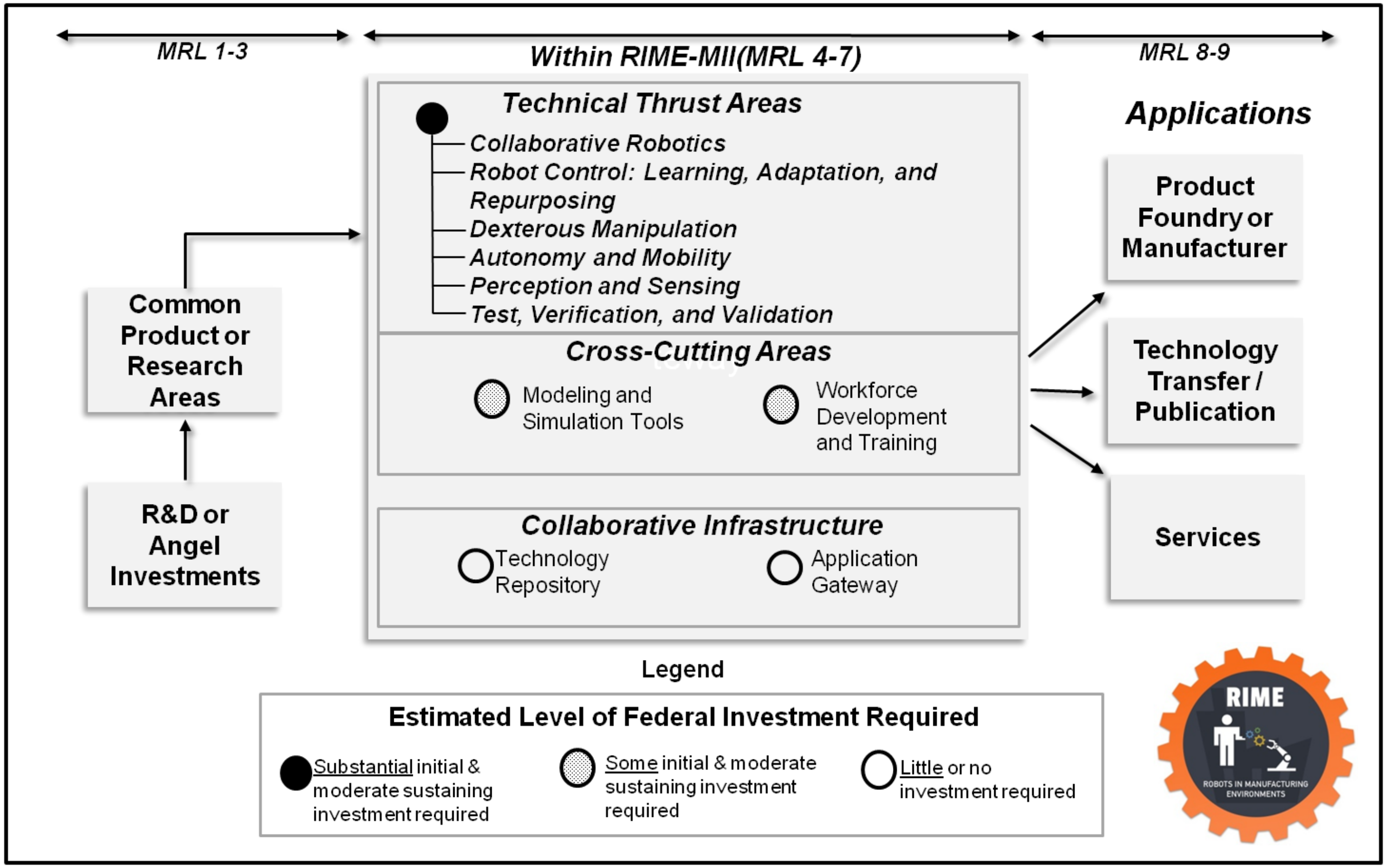


TECHNOLOGY/MANUFACTURING READINESS LEVELS

RIME ROBOTS IN MANUFACTURING ENVIRONMENTS MANUFACTURING INNOVATION INSTITUTE

NNMI Target (TRL 4–7 / MRL 4–7)

TRL 1:	Basic principles observed and reported	MRL 1:	Manufacturing feasibility assessed
TRL 2:	Technology concept and/or application formulated	MRL 2:	Manufacturing concepts defined
TRL 3:	Analytical and experimental critical function and/or characteristic proof of concept	MRL 3:	Manufacturing concepts developed
TRL 4:	Component and/or breadboard validation in a laboratory environment	MRL 4:	Capability to produce the technology in a laboratory environment
TRL 5:	Component or breadboard validation in a relevant environment	MRL 5:	Capability to produce prototype components in a production relevant environment
TRL 6:	System/subsystem model or prototype demonstration in a relevant environment	MRL 6:	Capability to produce prototype system or subsystem in a production relevant environment
TRL 7:	System prototype demonstration in an operational environment	MRL 7:	Capability to produce systems, subsystems or components in a production relevant environment
TRL 8:	Actual system completed and qualified through test and demonstrated	MRL 8:	Pilot line capability demonstrated; Ready to begin Low Rate Initial Production
TRL 9:	Actual system proven through successful mission operations	MRL 9:	Low rate production demonstrated; Capability in place to begin Full Rate Production

STANDARD DEFINITIONS

- Robotics – A branch of engineering and computer science that deals with design, construction, operation, and application of robots, as well as computer systems for their control, sensory feedback and information processing. This FOA specifically addresses the subset of robotics in manufacturing environments, or technologies dealing with autonomous and semi-autonomous machines (robots for short) that can work in constrained or dangerous environments or in support of manufacturing processes
- Artificial Intelligence - The ability of a non-living system to act appropriately in an uncertain environment using sophisticated mechanisms such as learning, reasoning, etc. The term "artificial intelligence" is typically applied when a machine mimics human "cognitive" functions such as "learning" and "problem solving. The central problems (or goals) of AI research include reasoning, knowledge, planning, learning, natural language processing (communication), and perception (Russell and Norvig 2003 & 2009)

STANDARD DEFINITIONS

- Collaborative Robotics in Manufacturing – A system or systems comprised of robots, software agents, smart sensors and related elements, working together with humans or with each other to comprehend, reason, plan, learn and ultimately support or execute manufacturing tasks. The collaborative interaction is defined as each element having individual goals/tasks and executing in a manner to support the goals/tasks of other elements in the system in a safe, secure and optimal way. This is an important area of robotics as it addresses how robots, including collections of robots, can collaborate with humans and with each other to achieve manufacturing tasks
- Autonomous Robots – The ability of an artificial intelligent robot system to independently compose and select among different courses of action to accomplish goals based on its knowledge and understanding of the world, itself, and the situation. An autonomous robot may also learn or gain new knowledge like adjusting for new methods of accomplishing its tasks or adapting to changing surroundings. Some modern factory robots are "autonomous" within the strict confines of their direct environment. The factory robot's workplace is challenging and can often contain chaotic, unpredictable variables, and as such, some degrees of freedom, or the amount of autonomy granted, may be limited

STANDARD DEFINITIONS

- Machine Perception – The capability of a machine or computer to interpret data in a manner that is similar to the way humans use their senses to relate to the world around them. Until recently input was limited to computers, but advances in technology, both in hardware and software, have allowed machine, including robots to take in sensory input in a way similar to humans (*Malcolm Tatum 2012)*

TECHNOLOGY THRUST AREAS

- **(1) <u>Collaborative Robotics</u>**: Currently, robots deployed in manufacturing environments tend to be large and are prohibited from being in the immediate working area of their human operators. To dramatically increase production throughput, "peer-like" interactions between humans and robots are necessary to minimize process variation and enhance operational efficiencies
  - **(1a) Design for Collaborative Robots**. Optimization software, along with similar advances in materials, mechanisms, fabrication techniques, and other novel concepts can enable the design of robots that ensures safety and maintains optimum productivity in the presence of humans in manufacturing environments. This sub thrust area encourages the physical design and integration of mature elements of various enabling design technologies into implementable solutions for human-robot collaboration.
  - **(1b) Human-Robot/Robot-Robot Interaction.** This includes the ability to provide intuitive interfaces that are simple, understandable and contain the intent for both the human and the robot. Resultant interactive behaviors should be transparent to allow for a peer-like relationship between robot-robot and human- robot.
  - **(1c) Supervisory Runtime Assurance.** During execution, runtime assurance shall provide for real time situation awareness, security (including cybersecurity), safety policy monitoring, debugging, fault protection, and system behavior verification and validation.

TECHNOLOGY THRUST AREAS

- **(2) <u>Robot Control: Learning, Adaptation, and Repurposing</u>**: Existing robots utilizing classic control techniques in manufacturing environments have limited learning, adaptation and repurposing capabilities. Next generation robotics should adopt advanced control techniques to efficiently share the workspace with users and other robots, and to continuously improve flexibility and performance via experiences within the workspace. A common and open framework is needed for innovation, reuse, and interoperability.
  - **(2a) Learning and Decision Making.** To assist in programming, learning by example may be employed in which the robot observes a human or other robot conducting tasks and repeats these behaviors. Decision making techniques can be used to examine impacts on task execution.
  - **(2b) Adaptation.** To be flexible in the manufacturing environment, adaptation can be employed and include open source, common architectures, and hardware design attributes to address variability.
  - **(2c) Rapid Repurposing.** The ability to rapidly, affordably, and safely repurpose robot platforms by hardware, software, and training.

TECHNOLOGY THRUST AREAS

- **(3) <u>Dexterous Manipulation</u>**: Next generation end effectors (also known as "end of arm tooling") should keep pace with challenges in manipulation of material systems (i.e. lubricated items, precision assembly). The identification, integration, and demonstration of advanced end effectors could include:
  - Use of virtual simulation methodologies to optimally inform the design of end effectors in the context of the task(s) to be performed.
  - Selection and implementation of the most appropriate methods for enabling dexterous and physical manipulation of objects (e.g. materials, mechanisms, use of energetic fields, or novel combinations thereof).
  - The appropriate use of sensing to inform adaptive and dexterous manipulation.

TECHNOLOGY THRUST AREAS

- **(4) Autonomous Navigation & Mobility**: The goal of this thrust is to advance the state of the art in mobility to access challenging environments. This implies a variety of movements such as crawling, climbing, accessing tight spaces. Similar to human navigation in the manufacturing environments, robots should be quick in their response to path planning and agile to dynamic obstacles in their intended path.
  - **(4a) Navigation, Dynamic Path Planning, Obstacle Detection and Obstacle Avoidance.** The ability to navigate in a dynamic manufacturing environment implies that the robot is aware of its size and configuration as well as the obstacles it must navigate through. Future autonomous navigation capabilities will require a balance between robustness (e.g. safety) and optimality (e.g. speed). Perception and sensing technologies are critical enablers for this capability.
  - **(4b) Mobility Enablers.** The proposers should address these issues as well as security of communications and impact of variability of a facility's infrastructure with respect to its effect on mobility, as appropriate. The desired future state is a robotic environment not constrained by power and communication limitations.

TECHNOLOGY THRUST AREAS

- **(5) Perception and Sensing**: Systems need to move beyond existing point measurements to a field representation (e.g. data fusion) to allow for intelligent situational awareness leading to successful task execution. The institute will not develop sensors but will integrate them. The integration of such perception and sensing systems require a thorough understanding of hardware and software implementations to properly embed solutions into robot operations and manufacturing processes. Interoperability and compatibility of sensors along with data reduction techniques, and advanced analytics will be needed to present a holistic interpretation for situational awareness.

TECHNOLOGY THRUST AREAS

- **(6) <u>Testing, Verification, Validation (TV&V)</u>**: Evidence-based methods and tools are required to verify and validate RIME prototypes and R&D projects for safety, security, and performance. New methods for software verification are necessary due to the non-deterministic nature of the collaborative human-robotic interactions in a potentially congested manufacturing environment. The general intent of this thrust area is to establish a plan that provides high confidence that a robotic system will perform its assigned tasks as intended within the constraints of safety, security, and performance. Applicants should provide a TV&V plan.
  - **(6a) Collaborative Environment Modeling and Simulation Tools.** Ability to model, conduct analysis, and verify design, safety and performance for robots and associated technologies, along with the capability to conduct relevant experiments with the models in the collaborative environment. The future state, enabled by the RIME-MII, will be new innovative modeling and simulation tools to address this.
  - **(6b) Robotics Software Testbed.** A shared-access test bed capability should be available to test and validate the embedded and other software in prototypes prior to integration into various operational manufacturing systems. It is desired to have automated software testing tools and capabilities to verify that the product code is free from errors early and throughout the development and integration cycle.

CROSS CUTTING THRUST AREAS

- **<u>Modeling and Simulation Tools</u>**: The Government expects RIME-MII to leverage mature modeling and simulation tools developed by the robotic industry and academia in order to robustly support each of the technology thrust areas. The vision for the Institute is to support a full range of design and modeling tools that facilitate product and process design and development, cost analysis, and trade-off studies.

- **<u>Education and Workforce Development</u>:** the integration of the educational programs, internships, and professional training and retraining that will advance the technical workforce for robots in manufacturing and testing technologies.
  - Strategy should include curriculum for all levels of education beginning grades K-12 and including community colleges, universities, trade schools, and "for profit" institutions.
  - Efforts should also be made to provide students with the critical manufacturing and entrepreneurial skills that will prepare them for a successful transition to the workforce and success in the development and commercialization of robot-related products.

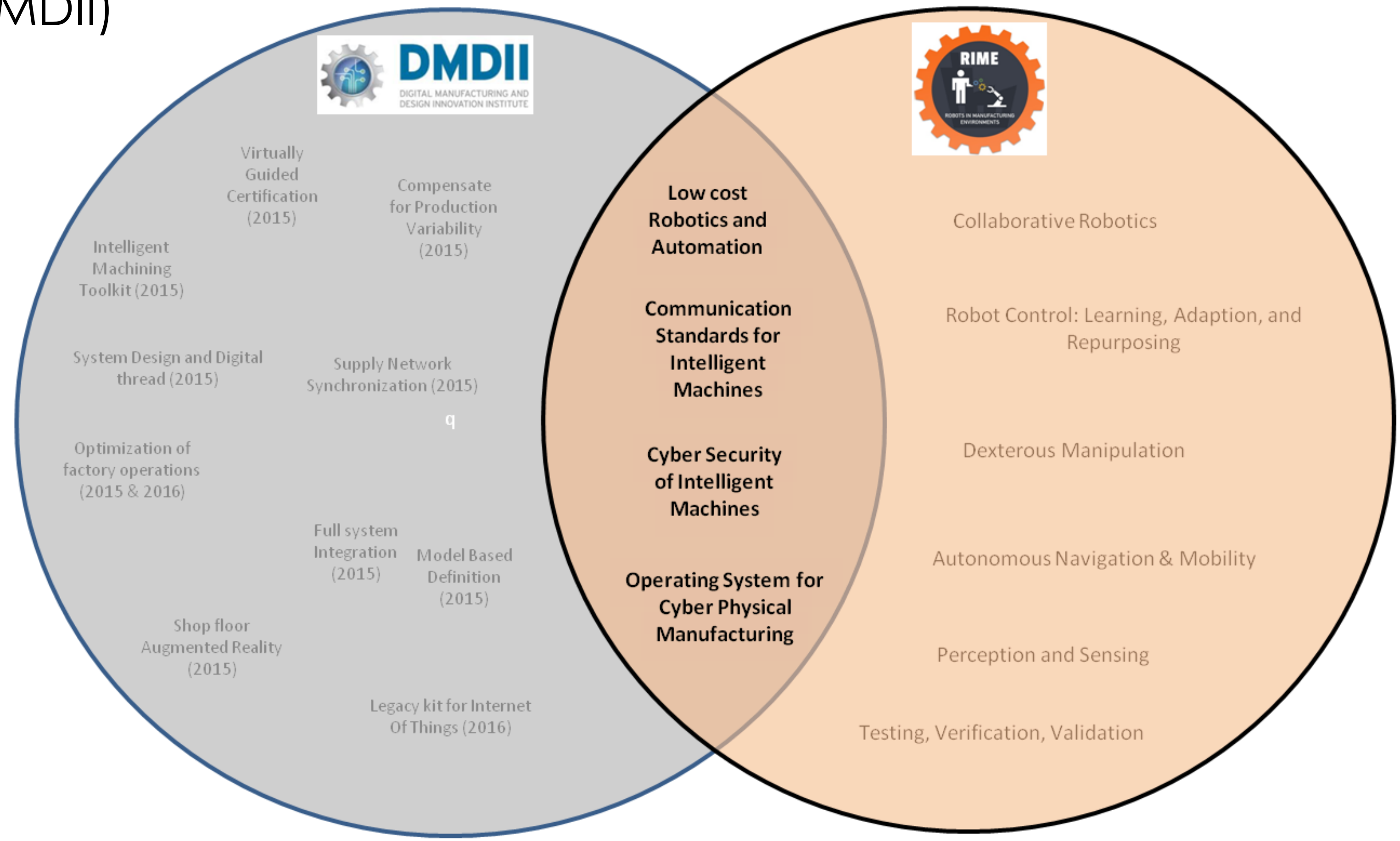
COLLABORATIVE INFRASTRUCTURE

- **Technology and Data Repository**: Currently, industry -- especially small and medium size enterprises -- does not have access to a repository where they can be updated with the latest robotics technology developments. The RIME MII should include this repository, to enable awareness and catalog new relevant technologies and processes in a shared knowledge management system. The government envisions a Test, Validation and Verification data repository as a subset of this overall data repository. This TV&V data repository should support relevant tool developments, inform regulatory policy and standards development.

- **Applications Gateway:** Currently, industry does not have access to a technology "matchmaker" to improve their odds of success when looking for partners in new robotics developing areas. The Institute should establish dynamic gateway in order to ensure RIME-MII is progressing toward a unified vision of delivering un-paralleled robotics technologies into the manufacturing domain.

SCOPE AND RELATIONSHIPS

- RIME-MII will have a close relationship and share common goals with other allied technology areas supported by other Institutes (Example: Digital Manufacturing and Design Innovation Institute – DMDII)



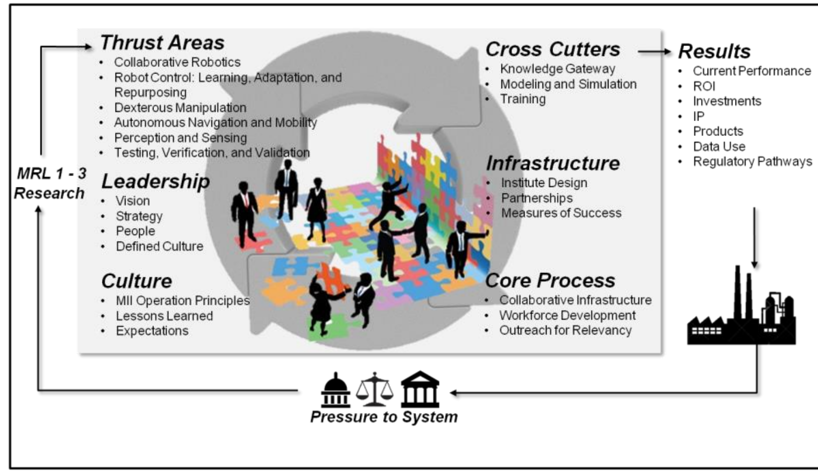
RIME-MII SUMMARY

ROBOTS IN MANUFACTURING ENVIRONMENTS
MANUFACTURING INNOVATION INSTITUTE

Technology Thrust Area Overview

- Collaborative Robotics: “Peer-like” interactions between human and robots to minimize process variation and enhance operational efficiencies.
- Robot Control: Learning, Adaptation, and Repurposing: Advanced control techniques to efficiently share the workspace with users, and to continuously improve flexibility and performance.
- Dexterous Manipulation: Next-generation end effectors for the manipulation of material systems.
- Autonomous Navigation & Mobility: Advance state-of-the-art in mobility to access challenging environments.
- Perception and Sensing: To enable intelligent situational awareness using available sensors.
- Test, Verification, Validation: Evidence-based methods and tools to verify and validate prototypes and projects for safety, security, and performance.

RIME-MII Operational Concept



- RIME-MII ecosystem assembles broad multi-disciplinary sub-recipients that are currently fragmented into a cohesive unit that provides prototyping and process advancements across multiple technology thrust areas

Funding and Acquisition Schedule

Fiscal Year	FY17	FY18	FY19	FY20	FY21	FY22	FY23	Total
Federal Govt Funding	$18	$18	$18	$18	$8	$0	$0	$80M
Non-Federal Government Cost Share (Minimum)								$80M
Total Program (Minimum)								$160M

- NOI released 20 June 2016; FOA released 26 July 2016
- Award Target: MID January 2017

Desired Results

- Bring together diverse and synergistic robotic science and engineering disciplines with traditional manufacturing processes
- Accelerate industrialization of emerging collaborative robotic technologies and enablers
- Establish a manufacturing hub that supports next-generation products, prototypes, and processes using a highly trained labor, state-of-the art technology, and a robust knowledge management system

EVALUATION CRITERIA

EVALUATION CRITERIA FACTOR-1 BUSINESS PLAN

- For the evaluation of **Factor 1**, the Government will assess the **Business Plan** which will describe how the RIME-MII will design, integrate, and sustain the ecosystem within the membership and its external stakeholders
- Discuss the coordination and operation of the RIME-MII through integration of the business plan sub-factors and enabling the advancement of the manufacturing readiness levels across the collaborative robotics in manufacturing related technology thrust areas
- Focused discussion on how these technology transitions will generate revenue for the RIME-MII
- Business and technical merits of the strategy for innovation and technology deployment/ dissemination should also be discussed
- **Factor 1 includes seven (7) sub-factors which will be evaluated and are equal in importance**

EVALUATION CRITERIA FACTOR-1 BUSINESS PLAN

- **Organization, Governance, and Operations**: Completeness and quality of the vision, culture, governance, and plan for the proposed organization and operation of the RIME-MII. This criterion includes the level and role of for-profit and non-profit organizations, institutions of higher education and multiple tiers of industry, end users, networked institutes, and the Government
  - Ability to bind all other participants to the terms and conditions of the award and to administer the award on behalf of the other participants
  - An agreement that the award terms and conditions take priority over those in the governance plan
  - Acknowledgement of the sub-recipients of their respective cost sharing and that no sub-recipient is responsible for the cost-sharing commitment of any other sub-recipient
  - The methods by which decisions will be made (e.g., with respect to operations, membership, capital investments, project selection, funding allocation, and progress toward self-sufficiency)
  - Draft RIME-MII organizational design, membership structure, governance agreements, and quality systems

EVALUATION CRITERIA FACTOR-1 BUSINESS PLAN

- **Management Capabilities**: Caliber (experience / knowledge), commitment, quality, leadership, technical capabilities and successful track record of the Lead Organization, the Lead Organization Director and key personnel to design, establish, grow, and sustain the RIME-MII. This includes the capacity and capability to execute the RIME-MII operational plan
  - Degree of leadership, technical capabilities and successful track record of the Lead Organization, Organization Director and key personnel and level of commitment to the RIME-MII
  - The relevant experience in successfully developing collaborative shared user facilities, capital equipment, and integrated workflows
  - Years of experience, areas of experience, relevancy of leadership and managerial experience and the ability to bring diverse stakeholders together for a common goal
  - Specific skills of key personnel necessary to execute the business of the RIME-MII and support the plan to take scientific efforts and translate them so that industry can understand and adopt

EVALUATION CRITERIA FACTOR-1 BUSINESS PLAN

- **Physical Infrastructure:** Soundness, availability, and access of the overall infrastructure proposed within existing facilities, including quality, capabilities, and availability of existing and proposed equipment, to include future infrastructure potential
  - Describe relevant physical infrastructure to include the sufficiency of geographic concentration to support the overall RIME-MII processes, including the manufacturing hub and other needed nodes
  - Capability to attain critical mass of capability and foster an active collaborative robotics for manufacturing innovation ecosystem
  - There is a preference for existing facilities that are currently owned or leased. **No new construction is allowed with federal funds**.

EVALUATION CRITERIA FACTOR-1 BUSINESS PLAN

ROBOTS IN MANUFACTURING ENVIRONMENTS
MANUFACTURING INNOVATION INSTITUTE

- **Cost Share**: The makeup, extent, and quality of commitments, of the cost share plan proposed over the life of the award. This includes the amount, source of the cost share, the timing of availability, the quality/applicability of any cost share, conditions of the cost share, and the impact of the cost share to the program over the period of performance
  - Overall cost share, source, category, and conditions associated with the cost share must be provided
  - A minimum 1:1 cost share against federal dollars is required, and greater cost share is encouraged
  - The cost share should be fully auditable and traceable
  - Cost share that is **evenly dispersed throughout the period of performance** is preferred over front-loaded or rear-loaded cost share
  - As a part of the Business Plan it is noted that cash contributions support the self-sustaining aspect of the RIME-MII more than in-kind contributions, although both categories are desirable and will be used to evaluate quality and make-up

EVALUATION CRITERIA FACTOR-1 BUSINESS PLAN

- **Intellectual Property (IP) Management:** Soundness of plan for managing and protecting intellectual property and the extent to which the IP management plan incentivizes private sector involvement as sub-recipients and sustainment
  - The treatment of confidential information between recipient and sub-recipients
  - The treatment of background IP
  - The treatment of inventions made under a project
  - The treatment of data produced, including technical data, software and documentation, under the project The treatment of any intellectual property issues that may arise due to a change in the make-up of sub-recipients
  - The handling of conflicts of interest of consortia or recipient and sub-recipients
  - The handling of disputes related to intellectual property between the recipient and sub-recipients
  - Government Use Rights
  - The manner in which Cyber Physical Systems Security measures will be addressed and managed to protect intellectual property

EVALUATION CRITERIA FACTOR-1
BUSINESS PLAN

- **Self-Sufficiency:** Viability of the plan for the RIME-MII to achieve financial self-sufficiency beyond the end of RIME-MII agreement performance period while maintaining an enduring industrial ecosystem and workforce development programs to meet technology needs
  - Plan for the RIME-MII to achieve financial self-sufficiency within the 7-year period of performance
  - Plan for developing additional revenue outside of the funding provided by the Government in support of financial independence and the plan for leveraging federal funds to optimize advancement of programmatic goals appropriate for the maturity of the technology under development
  - Describe the potential sources of outside funds (*e.g.*, membership fee structure, etc.)
  - Describe the management approach of focusing the research of the RIME-MII to develop the breadth and depth of research to specific areas that lend themselves to supporting a self-sustaining applied research RIME-MII
  - Include specific target metrics to track progress

EVALUATION CRITERIA FACTOR-1 BUSINESS PLAN

- **Defense and Economic Impact**: Viability of the plan for the RIME-MII to achieve financial self-sufficiency beyond the end of RIME-MII agreement performance period while maintaining an enduring industrial ecosystem and workforce development programs to meet technology needs
  - Relevance and potential U.S. economic impact (job creation, spin-off companies, etc.) of the proposed RIME-MII on the technology transition for commercial and defense applications
  - Relevance and contributions of the proposed effort to advance the manufacturing readiness level and accessibility to industry and/or the government, and government missions and the extent to which the overall RIME-MII proposal enables ecosystem development
  - Describe the proposed transition pathway to commercialization and give examples of previous successful transitions that have been executed.
  - Include more detailed expected contributions in the near (2-3 years), mid (4-7 years) and long term (8+ years)
  - Include any technology transfer and commercialization requirements or arrangements between the recipient and sub-recipients

EVALUATION CRITERIA FACTOR-2 TECHNICAL PLAN

- As part of the evaluation of **Factor 2**, the **Technical Plan**, the Government will evaluate **three (3) subfactors of equal importance** they are: **Technical Strategy**, **Innovation Beyond Current Practice and Technical Personnel Qualifications**

EVALUATION CRITERIA FACTOR-2 TECHNICAL PLAN

- **Technical Strategy**: Overall scientific and technical merits, quality, and level of innovation within the thrust areas and cross-cutting areas of the proposed approach with clear technology advancement goals or milestones. The breadth of the technical strategy to utilize each element of the RIME-MII ecosystem to its maximum potential in order to realize manufacturing advances
  - Approach to establish a national RIME-MII as a resource to focus on the complex issues in Robots in Manufacturing Environments, develop solutions to create cost-effective manufacturing capabilities that offset the risk to the U.S industrial base in adopting these new technologies, using a collaborative approach between industry, academia, government, and the workforce
  - Address the technical aspects of an end-to-end 'ecosystem' in the U.S. for Robots in Manufacturing Environments.
  - Provide a detailed structure addressing both DoD and commercial applications, with a focus on maturing technologies from Manufacturing Readiness Level 4 to 7.

EVALUATION CRITERIA FACTOR-2 TECHNICAL PLAN

- **<u>Innovation Beyond Current Practice</u>**: Relevance, approach and potential impact to defense and other government/ commercial applications as detailed in four example applied research projects that address each of the core technical areas of the RIME-MII. These four example applied research projects will be divided into quick start, stop-gap, cross cutter, and self-select project categories in order to evaluate the Applicant’s ability to exercise an ambitious and integrated RIME-MII technical plan

EVALUATION CRITERIA FACTOR-2 TECHNICAL PLAN

- **Example Manufacturing R & D Projects for Robots in Manufacturing Environments Technical Thrust Areas are: CRITICAL TECHNOLOGY, CROSS-CUTTER, QUICK-START and PROPOSER OPTION**

EVALUATION CRITERIA FACTOR-2
TECHNICAL PLAN

ROBOTS IN MANUFACTURING ENVIRONMENTS
MANUFACTURING INNOVATION INSTITUTE

- **Example Manufacturing R & D Projects for Robots in Manufacturing Environments: CRITICAL TECHNOLOGY**
- Provide a solution to a critical technology hurdle. As an example, As an example only, the applicant could outline the design, development, testing, and optimization of an innovative end-effector for next generation dexterous manipulation in assembly operations. The solution could employ enablers such as sensing and machine perception and intelligence to quantifiably prove safe and rapid manipulation. The solution could also include novel approaches for rapid repurposing of end effectors. Specific identification of current and related technology gaps, as well as defined baselines and metrics, are encouraged in order to measure and demonstrate performance improvements

EVALUATION CRITERIA FACTOR-2 TECHNICAL PLAN

- **Example Manufacturing R & D Projects for Robots in Manufacturing Environments: CROSS-CUTTER**
- Provide a plan for cross-cutting application of robotic capabilities in the manufacturing process. It is important for the applicant to address how cross-cutting technologies and thrust areas can be used to enhance the manufacturing process and end product. <u>As an example only</u>, the applicant could outline the application of robotics in the fabrication of parts for a component and the assembly of that component. The applicant could describe the solution in regards to cross cutting technologies and some or all of the six thrust areas (detailed in Appendix A, FOA) and how the employed technologies could be integrated into the process. The solution could also include the recognition of execution failures and means for recovery and/or correction. Process monitoring, real-time feedback on accuracy and precision, as well as the ability to autonomously plan and execute corrective actions could be included

EVALUATION CRITERIA FACTOR-2 TECHNICAL PLAN

- **Example Manufacturing R & D Projects for Robots in Manufacturing Environments: QUICK-START**
- A quick start project is one that is needed to facilitate a robust launch of the MII and is typically awarded in the standup phase prior to development of a technology roadmap. For example: Describe a framework for and implementation of an integrated and interactive RIME-MII knowledge and ecosystem repository dedicated to supporting the six major thrusts areas. This repository could allow the flow of information to and from small, medium, and large sized companies, universities, and government entities to deliver new products and services to diverse manufacturing sectors. A second example could be integration of the Applicant's TV&V infrastructure to allow for test, validation, and verification support for the first broad RIME-MII project awards

EVALUATION CRITERIA FACTOR-2 TECHNICAL PLAN

- **Example Manufacturing R & D Projects for Robots in Manufacturing Environments: PROPOSER OPTION**
- The fourth example project must be determined by the proposer and should highlight the <u>strengths and uniqueness</u> of the proposed RIME-MII technologies and team members. The project should be representative of one or more thrust areas.

EVALUATION CRITERIA FACTOR-2 TECHNICAL PLAN

- **<u>Technical Personnel Qualifications</u>**: The qualifications, capabilities and experience of the technical personnel
  - Illustrate the qualifications, capabilities and experience of the technical personnel and their ability to effectively manage and perform the research and development activities of the RIME-MII
  - Provide a summary of the plan for a proposed technical management structure of the RIME-MII
  - Short biographies for the key technical personnel
  - Qualifications of technical personnel include, but are not limited to, certifications, advanced degrees, professional licenses, etc. Capabilities include, but are not limited to, knowledge of the RIME-MII thrust areas
  - Relevancy and extent of work performed in the domain of the RIME-MII thrust areas

EVALUATION CRITERIA FACTOR-3 EDUCATIONAL AND WORKFORCE

- **<u>Education and Workforce Development Plan</u>:** The quality and degree of integration of educational and workforce/ professional development and training to support advancing technology will be evaluated
  - Description of the educational and workforce development components of the RIME-MII
  - Plan should consider all levels of education and position within the supply chain, including workforce retraining, 2 and 4 year undergraduate programs, graduate and post-graduate engagement, faculty engagement, internships, sabbaticals, and professional development necessary to ensure the next-generation robotics workforce has the knowledge and skill required to enable U.S. robotic manufacturing enterprises
  - The plan should establish an effective development with TRL/MRL 1-3 performers at colleges and universities and include how the RIME-MII will partner with intermediary organizations to enhance the involvement of students, teachers, and faculty
  - Degree of integration will be measured based on the level of consideration given to the inclusion of all levels of education and the opportunities provided by the RIME-MII for industrial personnel, faculty, students, researchers, and the commercial workforce to collaborate in the development of the materials, coursework and the research and practical experiences needed to ensure the availability of a workforce that is prepared for an effective transition to employment in the U.S. robotic manufacturing industry

EVALUATION CRITERIA FACTOR-3 EDUCATIONAL AND WORKFORCE

- **<u>Education and Workforce Development Plan (cont'd)</u>:** The quality and degree of integration of educational and workforce/ professional development and training to support advancing technology will be evaluated
  - Illustrate the design for education and workforce development as part of the RIME-MII operating structure
  - Provide a summary of the educational and workforce/professional development training components
  - Describe how the RIME-MII will partner with intermediary organizations, such as the National Institute of Standards and Technology Manufacturing Extension Partnerships, National Science Foundation Advanced Technological Education Centers, Engineering Research Centers, Industry/University Cooperative Research Centers, Trade Adjustment Assistance Community College and Career Training Centers, regional and state economic development organizations, and other intermediaries that provide manufacturing outreach and training
  - Plans for encouraging efficient access by graduate- and undergraduate-level researchers and community college technicians-in-training to specialized equipment and facilities in the RIME-MII and opportunities for students to interact with industry-based engineers should be included

EVALUATION CRITERIA FACTOR-4 COST

- **Reasonableness and realism of the proposed costs**, to include cost share, consideration of proposed budgets and funding profiles. Cost Realism Analysis will ensure proposed cost:
  - Is realistic for work to be performed
  - Reflects a clear understanding of the requirements
  - Is consistent with the unique methods of performance and material described in Applicants' technical proposals

INITIAL QUESTION AND ANSWER SESSION

LUNCH

ADDITIONAL QUESTION AND ANSWER SESSION

CONCLUDING REMARKS